COIL WINDING MACHINE

Cross-Reference to Related Applications

None.

Statement Regarding Federally Sponsored Research or Development

Not Applicable.

Appendix

Not Applicable.

Background of the Invention

1. Field of the Invention

This invention relates generally to coil winding machines and, more particularly, to a coil winding machine having an applicator head.

2. Related Art

Coil Winding Machines are known. For example, U.S. Patent No. 3,823,590 to Lang discloses a coil winding machine. The coil winding machine disclosed by Lang forms helical coils by rotating wire around a non-rotating mandrel. The Lang machine includes a frame 20 and a cantilevered tubular beam 28 connected to the frame. A non-rotating mandrel 45 extends through the tubular beam. One or more spools 32 having wire are mounted on the tubular beam. A coil forming rotor 50 removes wire from the spools and wraps it around the mandrel, thereby forming a helical coil.

Lang does not disclose an apparatus or a method for directly applying a coil wire perpendicular to a core wire (i.e., a mandrel). In the apparatus disclosed by Lang, wire is payed off over the end, or hub, of the spool. Removing wire from the spool in such a manner greatly increases the probability that the finished helical coil will have a discontinuity.

Additionally, it is known that some materials are more likely to produce a discontinuity in a finished helical coil. For example, some materials, such as stainless steel, have a significant shape memory. In other words, the material attempts to resume its original shape when released. The shape memory causes the finished helical coil to have a discontinuity, such as a wave or a distortion.

There has been a general interest in these materials which have desirable formed helical coil properties and, coincidentally, also have significant shape memory. For example, it has long been desirable to produce helical coils of stainless steel. However, because stainless steel has a significant shape memory, there has been great difficulty in producing acceptable helical wound stainless steel coils. The difficulty arises as the stainless steel wire is unwound from a spool and formed into a helical coil the wire attempts to resume its original shape thereby causing a distortion in the finished product. Known methods of producing stainless steel coils result in coils having significant waves, or distortion, in the coil. Similar results are obtained with other materials, such as platinum.

Thus, there remains a need in the art for a coil winding machine capable of producing distortion free helical coils.

Summary of the Invention

It is in view of the above problems that the present invention was developed. The invention is a coil winding machine for producing distortion free helical coils. The coil winding machine includes, among other things, one or more wire spools which are arranged in such a way that wire is payed off the spool perpendicular to a core wire. It has been found that paying off the wire from the spool in the same direction as it was put on, meaning tangentially and perpendicular to a spool axis, greatly decreases the probability that the finished coil will have a discontinuity. The perpendicular payoff is one aspect that allows for a distortion free coil.

In another aspect of the invention, there is provided an applicator head. The applicator head assists in guiding the wire as it is wrapped around the core wire. The applicator head is proximate to a spindle nose. As core wire exits the spindle nose, the applicator head assists in wrapping the wire around the core wire to produce a distortion free coil.

In another aspect of the invention, there is provided a back feed mechanism. The back feed mechanism allows for fine adjustment of the helical pitch. The back feed mechanism includes a sensor that measures wire pressure on the spindle nose. The sensor sends a signal to a controller that either speeds up the core wire travel speed or slows down the wrapping speed in order to maintain a specified pitch.

Further features and advantages of the present invention, as well as the structure and operation of various embodiments of the present invention, are described in detail below with reference to the accompanying drawings.

Brief Description of the Drawings

The accompanying drawings, which are incorporated in and form a part of the specification, illustrate the embodiments of the present invention and together with the description, serve to explain the principles of the invention. In the drawings:

Figure 1 is a front view of a coil winding machine;

Figure 2 is a top view of a coil winding machine;

Figure 3 is a detailed side view of a flywheel;

Figure 4 is a partial sectional front view illustrating a spindle nose and applicator head;

Figure 5 is a sectional side view of the applicator head; and

Figure 6 is a detailed front view of a spindle head assembly.

Detailed Description of the Preferred Embodiments

Referring to the accompanying drawings in which like reference numbers indicate like elements, Figures 1 and 2 illustrate a coil winding machine 10. The coil winding machine 10 includes a core wire feed assembly 50, a spindle head assembly 16, a pull roll assembly 18, and a cutter 22. The coil winding machine 10 is used to produce coiled wire. In some embodiments, the coil winding machine 10 includes a base 70, a touch screen monitor 72, and a controller 74.

The core wire feed assembly 50 includes a wire payoff 52 and, optionally, a wire straightener 56. A core wire spool 54 is rotatably connected to the wire payoff 52. The wire payoff 52 can accommodate core wire spools of various sizes. The wire payoff 52 includes a braking mechanism (not shown) to control the rotational speed of the core wire spool 54. The core wire spool 54 holds a core wire 100, which is used as a continuous mandrel. The phrase "core wire" is meant to include any item that may be used as a substantially continuous mandrel. Core wire 100 may be comprised of plastic or metal material. In the depicted embodiment, the core wire 100 is a metal wire having a diameter up to 0.250 inches (6.35 mm). However, shapes other than wire, such as a tube or a conduit, maybe used as a core wire. The wire straightener 56 is an item used to remove twists in the core wire 100.

The spindle head assembly 16 is used to rotate a flywheel 24. In the depicted embodiment, there is one flywheel. However, those skilled in the art will understand that multiple flywheels may be attached to the spindle head assembly 16. The flywheel 24 may rotate in a clockwise or counter-clockwise direction. The flywheel 24 holds wire spools 26 (best seen in Figure 3). The spindle head assembly 16 rotates the flywheel 24 and the wire spools about the coil wire 100. A spindle nose assembly 30 (best seen in Figures 3 and 4) is operatively connected to the spindle head assembly 16. The spindle nose assembly 30 does

not rotate.

The pull roll assembly 18 pulls the coil wire 100. The pull roll assembly 18 has a plurality of drive wheels 12 and a plurality of driven wheels 14. The drive wheels 12 are made of, or coated with, a frictional material to grip the driven wheels 14. For example, the drive wheels 12 may be made of urethane and the driven wheels 14 may be made of steel. In the embodiments having a tube or conduit core wire, the wheels 12, 14 are grooved. In the depicted embodiment, there are three sets of wheels. However, a greater or lesser number of wheels may be used. Three sets of wheels have been found to evenly distribute the load upon the core wire 100. The last set of wheels 13 may provide more than one function. As an example, the last set of wheels 13 not only pulls on the core wire 100, but also prevents the formed coil wire from unwinding before it is cut.

The pull roll assembly 18 is operatively connected to a power unit for rotating the drive wheels 12. For example, the drive wheels 12 are rotatably connected to a servo motor 66 and a transmission 68. In the depicted embodiment, the servo motor 66 is electrically connected to the controller 74.

In the depicted embodiment, the pull roll assembly 18 is pneumatically operated between an "up" position and a "down" position. For example, the pull roll assembly 18 may include a combination air cylinder and pressure regulator 19. However, the pull roll assembly 18 could also be mechanically or hydraulically operated. The pressure regulator regulates the amount of clamping force on the core wire 100.

Figure 3 illustrates a side view of the flywheel 24. As noted above, wire spools 26 are mounted on the flywheel 24. Each wire spool 26 holds wire 200. As examples, the wire 200 may be a platinum wire or it may be a stainless steel wire. In the depicted embodiment, there are four wire spools 26; however, a greater or lesser number of wire spools may be used.

Additionally, first wire guides 28 are also mounted on the flywheel 24. While in the depicted embodiment there are four first wire guides 28, a greater or lesser number of wire guides may be used. In some embodiments, there is also provided a second wire guide 29. The second wire guide 29 is arcuate and is placed adjacent to one of the spools 26. While in the depicted embodiment only one second wire guide 29 is shown, those skilled in the art will understand that a greater number of second wire guides may be used. For this last embodiment, the wire 200 would extend over the second wire guide 29 instead of the spool 26 as is depicted in Figure 3.

As best seen in Figure 6, the wire spool 26 includes a tensioning collar 27. Additionally, felts pads 25 are located on either side of the wire spool 26. The tensioning collar 27 presses against the wire spool 26 and the felt pads 25. The tensioning collar 27 is adjusted such that the wire spool 26 has a drag. The wire 200 is payed off the wire spool 26 at a controlled rate because of the drag.

Referring once again to Figure 3, an applicator head 32 is attached to the flywheel 24. Wire 200 travels from the wire spools 26, across the wire guides 28, and through the applicator head 28. Thereafter, wire 200 is wrapped around the core wire 100 to produce a formed coiled wire. The wire spools 26 and the applicator head 32 are arranged in such a way that the coil wire 200 is payed off perpendicular to the core wire 100. This eliminates or substantially reduces waves or distortion in the finished coil wire. The flywheel 24 also includes a counterweight 33 opposite the applicator head 32. The counterweight 33 counterbalances the mass of the applicator head 32.

Figure 4 illustrates a spindle nose 31 and the applicator head 32. The applicator head 32 is forward of the spindle nose 31. The applicator head 32 includes guide pins 34. The guide pins 34 guide the wire 200 through the applicator head 32. A hinged cover 38 covers

the wire 200 as it goes through the applicator head 32. The applicator head 32 includes a spacer 37. The spacer 37 guides the wire 200. In the depicted embodiment, the spacer 37 is made from plastic shim stock and is 0.002 inches (0.05 mm) thicker than the wire 200.

Figure 5 illustrates the applicator head 32. The applicator head 32 includes a pressure adjustment plate 40, a pressure adjustment screw 44, a locknut 45, and pressure pads 42. The pressure adjustment screw 44 is used to adjust the tension in the wire 200 as it is wrapped around the core wire 100. In the depicted embodiment, the pressure adjustment plate 40 is a resilient steel plate and the pressure pads 42 are made of felt. The pressure pads 42 encapsulate the wire 200. The applicator head 32 includes inserts 36 and the spacer 37. The applicator head 32 includes an arm 39. The arm 39 places the inserts 36 and the spacer 37 proximate to the spindle nose 31. The spacer 37 is located between the inserts 36. The combination of the inserts 36 and the spacer 37 encapsulate and guide the wire 200. In the depicted embodiment, the inserts 36 are made of carbide but other materials, such as tool steel, may be used. What is important is that the inserts have good wear characteristics without features that would scratch the wire 200.

Figure 6 illustrates the spindle head assembly 16. The spindle head assembly 16 has a spindle input 58. The spindle input is operatively connected to a spindle (not shown) which is encased within a spindle head 46. In the depicted embodiment, the spindle input 58 is a pulley but other devices, a gear for example, may be used. The spindle input 58 is operatively connected to a power unit (not shown), such as a servo motor. In the embodiment depicted in Figure 2, the spindle head assembly 16 includes a rotational sensor 47 for counting the revolutions of the flywheel 24. The rotational sensor 47 is connected to the controller 74. The spindle input 58 is rotated by the power unit which in turn causes the flywheel 24 to rotate. The flywheel 24 rotates about the spindle nose assembly 30. The spindle nose

assembly 30 itself does not rotate. Core wire travels 100 through the spindle nose assembly 30. Wire 200 is wrapped around the core wire 100 at the spindle nose 31. One can control the pitch of the formed coil wire by adjusting the speeds of the core wire travel speed and the wrapping (flywheel) speed in relation to one another. For example, the controller 74 may be preprogrammed or manually programmed to vary the pitch of the formed coil wire. In this example, the controller 74 is manually programmed through the use of the touch screen 72.

In some embodiments it may be desirable to have a fine adjustment of the core wire speed to accurately maintain a specified pitch. In this case, some mechanism is required to physically measure the difference between the core wire speed in relation to the wrapping speed. Here, there is provided a back feed mechanism 60. The back feed mechanism includes a sensor 62 and a sensing plate 64.

For embodiments having the back feed mechanism 60, the spindle nose assembly 30 is movable fore and aft. In the depicted embodiment, the spindle nose assembly 30 is moved axially via a force air cylinder 80. In contrast, in the embodiments having an applicator head 32, the spindle nose assembly 30 is fixed axially. The applicator head 32 is not used in conjunction with the back feed mechanism 60. A position adjusting air cylinder 82 is used to move the spindle from a first position for use in conjunction with the applicator head 32 to a second position for use in conjunction with the back feed mechanism 60. The position adjusting air cylinder 82 may not be used in all embodiments, and those skilled in the art will understand that the spindle may be permanently locked in either the first or second positions.

When the coil winding machine 10 is first started, spindle nose assembly 30 is in a neutral position. In the depicted embodiment, the sensor 62 has a 10 Volt range and the spindle nose assembly 30 is moved axially into a neutral position when the sensor output is 5 Volts. As the coil winding machine 10 operates, wire 200 is wrapped around the core wire

100. If the wire 200 is wrapped around the core wire 100 faster than core wire travel speed can accommodate, then the wire 200 will have a tendency to press against a spindle nose collar 48. This pressure against the spindle nose collar 48 causes the spindle nose assembly 30 to move rearwardly. This rearward movement cause the sensing plate 64 also to move rearwardly. Thus, the sensing plate 64 moves toward the sensor 62. The sensor 62 sends a signal to the controller 74 which can speed up the core wire speed or slow down the wrapping speed. In this manner, a uniform wrap at a desired pitch can be achieved.

In some embodiments, it is desirable to apply a UV-glue prior to cutting the formed coil wire. As best seen in Figures 1 and 2, a glue applicator 20 is provided to apply the UV-glue prior to cutting the formed coil wire. The glue prevents the formed coil wire from unraveling when it is cut. The glue applicator 20 applies and cures the glue to the formed coil wire. The glue applicator 20 is operatively connected to the pull roll assembly 18.

In a final step, the formed coil wire is cut by the cutter 22. As examples, the cutter 22 may take the form of a shearing mechanism, a saw mechanism, or an abrasive cutter. By adjusting the frequency of the cutting action of the cutter 22, one can adjust the length of the formed coil wire. In the depicted embodiment, the cutter 22 is operatively connected to the controller 74. As an example, the controller 74 may be preprogrammed or manually programmed to vary the length of the formed coil wire.

In operation, a core wire spool 54 having core wire 100 is placed on the wire payoff 52. The core wire 100 is strung through the straightener 56, the spindle, and the pull roll assembly 18. The air cylinder 19 is engaged such that the core wire 100 is caught between the drive wheel 12 and the driven wheels 14.

Next, wire spools 26 having wire 200 are placed on the flywheel 24. The wire 200 is strung through the first wire guides 28 and over the second wire guides 29. The wire 200 is

then strung over the pressure pad 42 and through the wire guide pins 34. The wire 200 is then strung through the spacer 37. Thereafter, the insert 36 is placed over the wire 200 and the hinged cover 38 is closed.

Next, an operator may manually specify a desired pitch and length of the formed coil wire via the touch screen 72. Alternatively, the desired pitch and length may be pre-programmed into the controller 74. The desired pitch and length are stored in the controller 74. The coil winding machine 10 is started and the wire 200 is wrapped around the core wire 100. The completed wrap travels through the glue applicator 20 where UV glue is applied. Finally, cutter 22 cuts the formed coil wire to the desired length.

To assemble the coil winding machine 10, one first provides the base 70. Next, the spindle head 46 is mounted on the base 70. Next, the spindle nose assembly 30 is mounted to the spindle head 46. Then, the flywheel 24 is rotatably mounted to the spindle head 46. Next, one or more wire spools 26 is connected to the flywheel 24. Then, one or more wire guides 28, 29 is connected to the flywheel 24. Next, the applicator head 32 is connected to the flywheel 24. Thereafter, the pull roll assembly 18 and the core wire feed assembly 50 are connected to the base 70. The glue applicator 20 is connected to the pull roll assembly 18. Next, the cutter 22 is connected to the base 70. Then, the touch screen 72 and the controller 74 are connected to the base 70. Finally, the controller 74 is electrically connected to the core wire feed assembly 50, the spindle head assembly 16, the pull roll assembly 18, and the cutter 22.

In view of the foregoing, it will be seen that the several advantages of the invention are achieved and attained.

The embodiments were chosen and described in order to best explain the principles of the invention and its practical application to thereby enable others skilled in the art to best

utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated.

As various modifications could be made in the constructions and methods herein described and illustrated without departing from the scope of the invention, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative rather than limiting. For example, while four wire spools are shown in the depicted embodiments, a greater or lesser number of wire spools may be used. Thus, the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims appended hereto and their equivalents.